A new test proves how to make the Event Horizon Telescope even better

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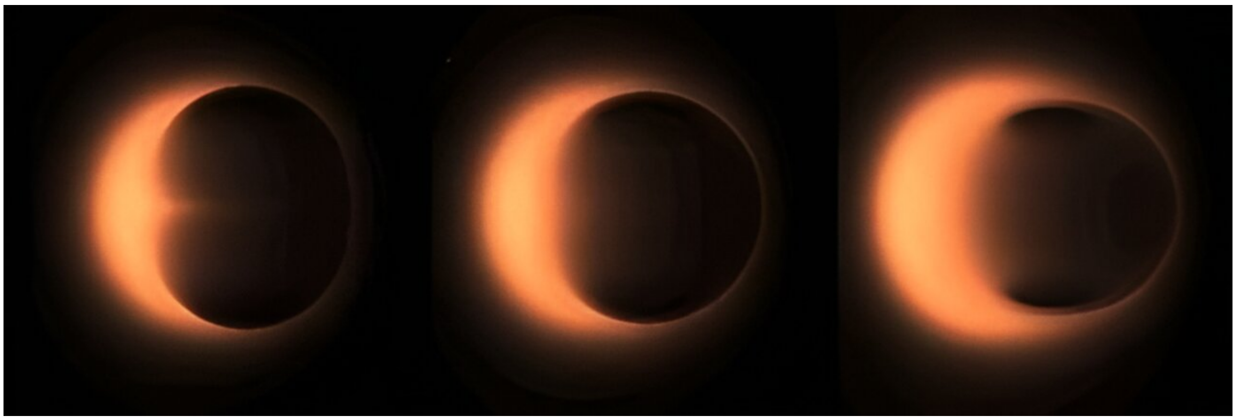


Researchers using the Event Horizon Telescope hope to generate more and better images like this of supermassive black hole Sag. A's event horizon. Credit: EHT

Want a clear view of a supermassive black hole's environment? It's an incredible observational challenge. The extreme gravity bends light as it passes through and blurs the details of the event horizon, the region closest to the black hole. Astronomers using the Event Horizon Telescope (EHT) just conducted test observations aimed at "deblurring" that view.

The EHT team collaborated with scientists at the Atacama Large Millimeter/submillimeter Array (ALMA) and other facilities to do the tests. The antennas detected light from the centers of distant galaxies at a radio frequency of 354 GHz, equivalent to a wavelength of 0.87 mm.

This pilot experiment achieved observations with detail as fine as 19 microarcseconds. That's the highest-ever resolution ever achieved from Earth's surface. Although there are no images from the tests, the observations "saw" strong light signals from several distant galaxies—and that was only using a few antennas.

Once the team focused the full worldwide EHT array on targets, they could see objects at a resolution of 13 microarcseconds. That's about like looking at a bottle cap on the surface of the moon—from Earth's surface!

Sharpening the Event Horizon Telescope

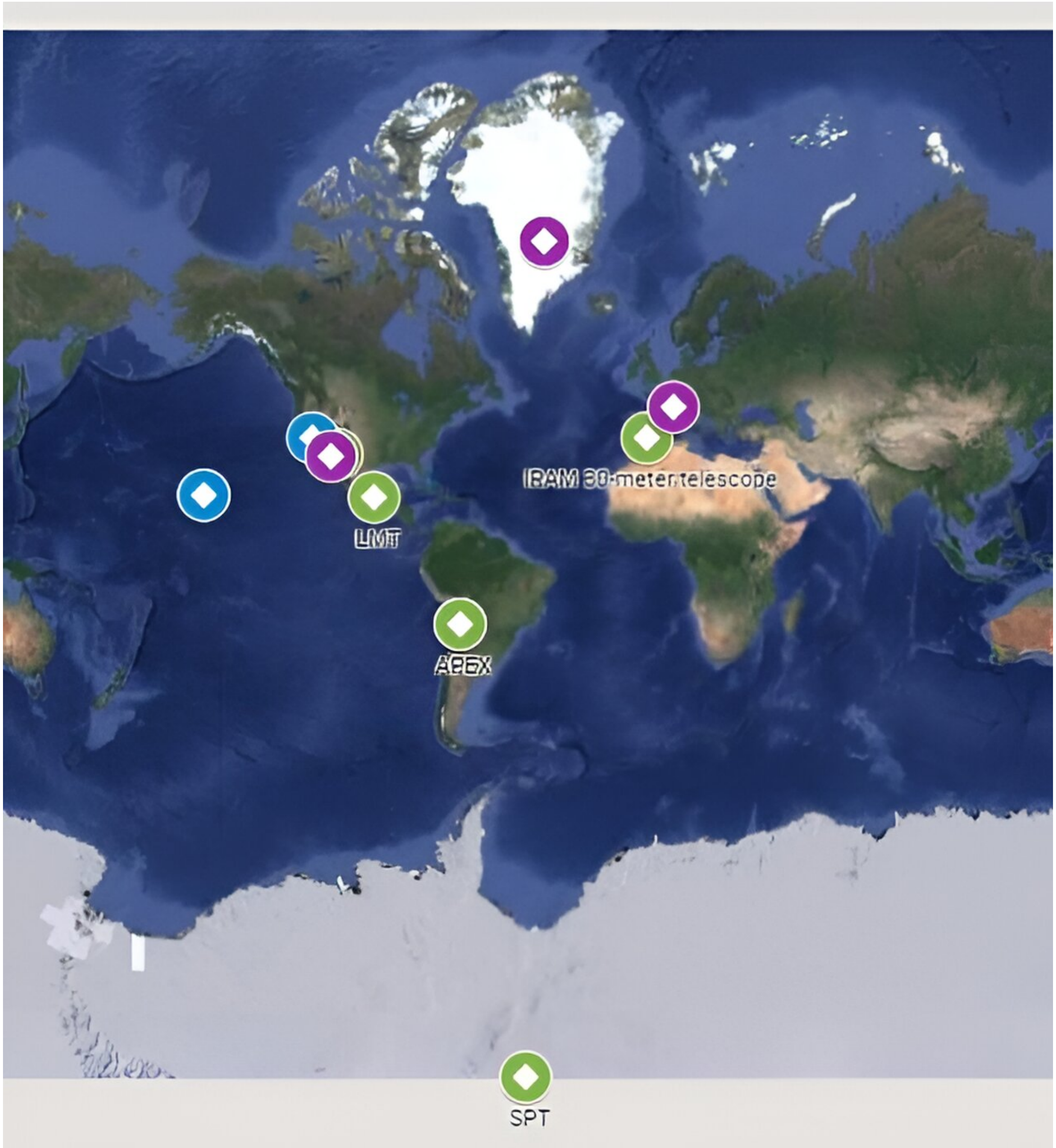
These observational tests are a big breakthrough because it means scientists can make images of black holes that are 50% sharper than previous observations. The EHT's groundbreaking first observations of M87's black hole and Sagittarius A* in our galaxy happened just a few years ago, at a wavelength of 1.33 mm. Those images were amazing, but the science teams wanted to do better.

"With the Event Horizon Telescope, we saw the first images of black holes using the 1.3-mm wavelength observations, but the bright ring we saw, formed by light bending in the black hole's gravity, still looked blurry because we were at the absolute limits of how sharp we could make the images," said the observation's co-lead Alexander Raymond of the Jet Propulsion Laboratory.

"At 0.87 mm, our images will be sharper and more detailed, which in turn will likely reveal new properties, both those that were previously predicted and maybe some that weren't."

According to EHT Founding Director Sheperd "Shep" Doeleman, an astrophysicist at the CfA and co-lead on a recent paper about the observations, the recent tests will improve the view of our galaxy's central supermassive black hole, as well as others.

"Looking at changes in the surrounding gas at different wavelengths will help us solve the mystery of how black holes attract and accrete matter, and how they can launch powerful jets that stream over galactic distances," he said. In addition, the new technique should reveal even more dim, distant black holes than the EHT has already seen.



The current locations of observatories that make up the full Event Horizon Telescope. Credit: EHT

Creating a big radio eye to study black holes

Think of the Event Horizon Telescope as a giant, Earth-sized virtual radio telescope. Instead of one massive dish the size of our planet, it links together multiple radio dishes across the globe. The technique is called "very long baseline interferometry" with each observatory sending its data to a central processing center.

For this test, the array consisted of six facilities, including the Atacama Array. The experiment succeeded in expanding the wavelength range of the EHT. Usually, to get better resolution, astronomers have to build bigger telescopes, but this one's already Earth-sized. So, goosing the wavelength was the only choice.

The test observations at higher resolution mark the first time the VLBI technique was used successfully at a wavelength of 0.87 mm. It's a challenging measurement to make because water vapor in the atmosphere absorbs more waves at 0.87mm than at 1.3mm. As a result, astronomers worked to improve the EHT's resolution by increasing the bandwidth of the instrumentation. Then, they had to wait for good observing conditions at all the test sites.

The improvements should allow astronomers to get high-fidelity "movies" of the event horizon around a black hole. Of course, astronomers want more upgrades to the existing EHT arrays. Planned improvements include new antennas, as well as improvements to detectors and other instruments. The result should be some pretty spectacular images and animations of material trapped in the extreme gravitational clutch of a black hole.

Revisiting old black hole friends

Future observations will include return observations of the supermassive black holes in M87 and the heart of the Milky Way galaxy. Both are surrounded by accretion disks full of material swirling into the black hole. Once that material crosses the event horizon (the gravitational point of no return), it's gone forever. So, it's important to track that kind of action around a black hole. That's where the EHT comes in handy.

According to Shep Doeleman, the details should be amazing. "Consider the burst of extra detail you get going from black and white photos to color," he said. "This new 'color vision' allows us to tease apart the effects of Einstein's gravity from the hot gas and magnetic fields that feed the black holes and launch powerful jets that stream over galactic distances."

With this in mind, he added that the Collaboration is excited to reimage M87* and Sgr A* at both 1.3mm and 0.87mm and move from detecting black hole "shadows" to more precisely measuring their sizes and shapes, which can help to estimate a black hole's spin and orientation on the sky.

If all that happens as they hope, the 400-member EHT consortium will certainly be able to fulfill its founding aim. That's to provide the most detailed radio images of the mysterious beasts that lurk in the hearts of most galaxies.

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